

SEMIANNUAL REPORT OF ACTIVITIES

SUPPORTED BY AND RELATED TO

NASA GRANT NsG-269-62

MULTIDISCIPLINARY RESEARCH IN SPACE-RELATED SCIENCE AND TECHNOLOGY

31 December 1965

(This report covers only the three-month interval ending 31 December 1965; in the future the semiannual reports will be issued June 30 and December 31, whereas in the past the dates were March 31 and September 30.)

This research program is carried out in
The Earth and Planetary Sciences Laboratory

Francis S. Johnson, Director

This Laboratory is one of several within
The Southwest Center for Advanced Studies

Lloyd V. Berkner, Director

The Southwest Center for Advanced Studies is the research arm of
The Graduate Research Center of the Southwest

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PREFACE

This report includes a summary of all activities supported by NASA Grant NsG-269-62. It covers a period of only three months rather than the usual period of six months, and contains a lesser amount of detail than is usually included in the semiannual report. For a more complete description of the research activities, reference should be made to the semiannual report dated 30 September 1965.

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FUNDAMENTAL RESEARCH IN EARTH AND PLANETARY SCIENCES

A BROAD PROGRAM SUPPORTED BY OR RELATED TO

NASA GRANT NsG-269-62

SOUTHWEST CENTER FOR ADVANCED STUDIES

31 DECEMBER 1965

A. General Objectives

The overall objective of the research program of the Earth and Planetary Sciences Laboratory at the Southwest Center for Advanced Studies is to develop as fully as possible an understanding of the earth including its atmosphere and the processes by which it has reached its present state. This same objective applies with regard to the planets, the moon, and the interplanetary or solar environment in which they are located. Also included is an interest in cosmology. The characterizing feature of the entire research program is its breadth, which enables each research area to draw strength from the other research areas. The programs supported at SCAS by NASA Grant NsG-269-62, and closely allied programs supported by NASA and other agencies, thus constitute a broad interdisciplinary approach to space research.

The basic NASA grant is carefully apportioned to specific research projects in order to assure that the supported activities are highly responsive to NASA scientific program objectives. In addition to the basic grant, supplemental funding from the program offices was provided through the grant instrument, starting in April, 1964; this provided additional

support for specified portions of the program. Further, many contracts with NASA provide for specific experiments to be performed in space vehicles. A number of grants and contracts with other government agencies involve activities that relate to NASA interests. As a result, several programs of the Laboratory not supported by NASA provide very direct advantages to NASA through the development of theories, sophisticated techniques, and equipment that can be applied advantageously to future objectives of the space program. A summary of contracts and grants from all government agencies is presented in Section E.

The research activities at SCAS mainly support the following four program areas of the NASA Space Sciences program: Planetary Atmospheres, Ionospheric and Radio Physics, Particles and Fields, and Planetology. The recent rapid development at the Center of a research program in molecular biology may well lead to interdisciplinary research in exobiology.

B. Research Program

The program descriptions described under this section describe the total research effort of the Center relevant to NASA's interests without respect to sources of funding, whether by the Center, NASA, or other sources. However, sources of funding other than the NASA grant are usually mentioned. The interlocking features of the research program make its orderly description difficult. The division into the different areas described below is rather arbitrary, but it serves to illustrate the apportionment of effort.

1. History of the Earth's Atmosphere

The development of the earth's atmosphere over geological time

has been traced on the basis of geological evidence and photochemical constraints. The ideas involved in this research have been very useful in understanding the development of atmospheres on other planets, especially Mars.

2. Atmospheric Structure

The research in atmospheric structure continues to emphasize transport processes, atmospheric oscillations, and composition structure.

3. Ionospheric Structure

(a) Diffusion and Drift

Calculations are being made of ion diffusion and drift in the upper F-region to increase our understanding of the predominant physical processes that control this region of the ionosphere.

(b) D-Region

Current effort is being directed toward the formulation of a hydrodynamic approach to the problem of waves in a warm, lossy, magnetoplasma, such as the lower ionosphere. The immediate goal has been to show that the hydrodynamic approximation to the Boltzmann equation can yield reasonable results in the solution of boundary value problems for which experimentally determined answers are available. One of these, the spherical resonance probe in an isotopic plasma, is readily amenable to solution, and the theoretical expressions for r.f. admittance and d.c. probe current are in fairly good agreement with published experimental results. While this problem can be solved more accurately using the Boltzmann equation, the success of the hydrodynamic approach indicates the applicability of the latter to more complicated geometrical boundaries, such as the dipole antenna, and as well to magnetoplasmas.

Attempts to relate the Z-trace phenomena, often observed in ionograms, to the electroacoustic-like waves of warm plasma theory have yielded only negative results.

(c) Multiple Ionospheric Probe

Data reduction is continuing on the September flight results of the multiple ionospheric probe instrument package. The third launching has not yet been definitely scheduled, but it is planned for the end of the first quarter, 1966, to coincide with launchings of two other rockets instrumented by ITSA (Boulder, Colorado) for a pulsed ionospheric probe to which are now being added high frequency capacitance probes similar to those on the M.I.P., but using the conical nose tip of the payload.

4. Plasmas

Some measurements of capacitance as a function of frequency have been made in a laboratory chamber, and approximate but reasonable values of collision frequency have been deduced.

A new grant has been assured (effective February 1, 1966) to pursue related Langmuir probe studies.

5. Geomagnetic Rapid Variations

Since June, 1964, the Southwest Center for Advanced Studies of the Graduate Research Center of the Southwest has conducted a balanced theoretical and experimental study of magnetohydrodynamic (MHD) pulsations of the earth's magnetic and electric fields at the Dallas Hydromagnetic Observatory. Emphasis during the first year was on establishing the experimental program. As a result, the data acquisition system is substantially complete. At this time, program efforts are being directed

toward characterizing the behavior of these MHD wave-derived "micro-pulsations" of the earth's electromagnetic field.

The range of frequencies covered in the program has recently been extended by the installation of a Rubidium vapor magnetometer system. This unit, the "ASMO," which is operated by the U. S. Coast and Geodetic Survey, provides a punched paper tape output each minute from which may be computed the D, H, and Z components of the earth's magnetic field. This is equivalent to having a standard magnetogram in digital form with sample values each minute. In this way a range from 0 to 10^{-2} cps is covered with a sensitivity of about 0.2 gamma.

6. Energetic Particles

(a) Neutron Monitors

There is a continuing program of operation of two large IQSY neutron monitors, one at Fort Churchill, Manitoba, the other at Dallas. These monitors constitute a portion of a world-wide network established at the start of the IQSY to permit resolution of the hour-to-hour changes in the cosmic ray flux of energy >1 Bev. The Fort Churchill monitor is also used by a number of other scientific groups as a source of quick-access data to choose suitable times to launch balloon-borne experiments to study cosmic ray phenomena. In this respect, the monitor is considered to be a portion of the range support equipment at the Churchill research range. The neutron data are circulated, on a regular basis, to scientific workers throughout the world. They are also routinely reported in the CRPL monthly reports, "Geomagnetic Data."

(b) Balloon Program

A balloon program has been mounted to observe:

- (1) Fast Intensity Fluctuations
- (2) X-Ray Astronomy
- (3) γ -Ray Astronomy
- (4) Bremsstrahlung X-Rays

(c) Satellite Instrumentation

Equipment to measure the degree of anisotropy of the cosmic radiation in the range 7.5 to 100 Mev/nucleon was flown on the deep space probe, Pioneer A, launched December 16, 1965.

(d) ISIS, The Soft Particle Spectrometer

A soft particle spectrometer is being developed for the ISIS-A satellite under NASA Contract NAS5-9112. The engineering model is now essentially complete and undergoing tests; it appears to be satisfactory. Delivery to the spacecraft contractor is scheduled for late January, 1966.

7. Auroral Current Systems

Dr. J. A. Fejer is working on an extension of previous attempts to explain the so-called auroral electrojets, the ionospheric currents that flow in an east-west direction in the auroral zones and are believed to cause the large magnetic disturbances at auroral latitudes.

8. Planetary Atmospheres

There has been a continuing interest at SCAS in the atmospheres of the planets, although little effort has been expended on this since the available data have been so sparse in the past. Mariner IV data have, however, made consideration of the Martian atmosphere much less speculative. Dr. F. S. Johnson has interpreted the ionospheric data obtained at occultation in terms of atmospheric properties. The conclusion is that the atmosphere is exceedingly cold and that there is no thermosphere.

9. Atmospheric Chemistry, Reaction Kinetics

Quantitative knowledge of the sources of the chemically and electronically unstable species observed in the atmosphere, as well as the mechanisms resulting in their eventual destruction, is of extreme importance in the construction and understanding of detailed atmospheric models. Although the current stage of technological development precludes measurement under simulated atmospheric conditions, experiments conducted at measurably high concentrations can be extrapolated back to atmospheric conditions provided the detailed microstructure of the reactions is sufficiently well known. For this reason the laboratory program in reaction kinetics has been established at SCAS.

10. Atmospheric Chemistry, Airglow

A grille spectrometer of very high speed has been built at SCAS, and the instrument is now installed at a field location near the Irving Langmuir Laboratory near Socorro, New Mexico. This site has an altitude of 10,600 feet and an unobstructed sky view down to within 5° of the horizon.

11. Infrared Studies

There is a theoretical infrared program at SCAS. Work in this field has been divided between studies of the interaction of electromagnetic radiation with absorbing particles such as are found in the atmosphere and studies of the absorption of laser radiation along atmospheric slant paths.

12. Lunar Investigations

(a) Surface Reflectivity

A study has been undertaken on the photometric studies of diffusely

reflecting surfaces. Further improvement in the test equipment has been accomplished, measurements on many more samples have been carried out in a variety of illuminating and detecting arrangements; this has confirmed our earlier laboratory findings of a sharp retrodirective peak in the reflection curve for almost all common materials. The instrument has recently been modified to permit measurement of the intensity of the reflected light to within $\frac{1}{4}^{\circ}$ of zero phase angle. It was found that the intensity in the central peak increased still further from that at $3/4^{\circ}$ in the earlier measurements.

(b) Lunar Atmosphere

Attention has been given to the probable constituents of the lunar atmosphere and their geophysical significance. The suitability of coincidence mass spectrometer is being investigated for measuring the lunar atmosphere.

13. Geochemistry

(a) Geochronology

Isotope dilution analyses are being made to confirm the concentrations of Rb and Sr made by X-ray fluorescence and atomic absorption photometry. It is clear that no major change in the conclusions reported previously will result, but the precision of the concentrations will be increased greatly.

Digital processing equipment has been adapted for double collector measurements on the mass spectrometer. In addition, methods for controlling the scan from the memory of the digital processor are being developed.

(b) Experimental Petrology

The development of the high pressure temperature equipment has proceeded apace and the first calibrations will be completed before the end of the year.

Two hundred thin sections of peridotite and eclogite inclusions from the South African diamond pipes have been examined. Unit cell dimensions have been measured for the olivine and garnet from about half of the 200 samples. Indications of crystal liquid equilibrium have been found in almost all the specimens examined.

14. Planetary Structure

The work on the theoretical seismograms has continued. A further paper has been prepared.

15. Paleomagnetism

Studies of North African samples have been carried forward and a review article has been prepared.

16. Kinetic Theory

Work proceeded on a general-relativistic kinetic theory of gases. We are motivated by the desire to obtain a model of matter in Einstein's theory of gravitation that seems more appropriate than that of continuum mechanics, for example in the description of stars, galaxies, and universes.

17. Spinors and Cosmology

Work on spinor analysis has continued. A book on this subject is still being actively prepared and will be published by Cambridge University Press. Several new chapters have recently been written.

18. Mathematical Developments

A new formalism (closely allied to spinor formalism: less general but even more compact) has been developed which is particularly well-adapted to the construction of exact solutions and to the study of gravitational radiation.

19. Gravitational Radiation

We have devised a rather more general method than was previously known for the construction of stationary solutions by modifying an appropriately chosen static solution of the twist-free expanding system.

20. Classical Relativity

A puzzling point in the well-known Kruskal-Schwarzschild metric of an isolated mass point in general relativity is the sudden reversal in the direction of penetrability of the event-horizon at one given instant. By finding a "cosmological" version of this metric in the form of a test gas which first explodes and then implodes, we have succeeded in understanding physically the properties of the horizon. A paper on this subject is in preparation.

21. Equation of Motion

Standard approximation methods in Einstein's general theory of relativity build a solution to the field equations by means of an expansion of the metric in a power series of a parameter, using the Minkowskian metric as a background field.

22. Elementary Particles

Among the problems most recently under consideration is the problem of the Spectrum Generating Algebras (SGA). It is an outgrowth

of two new ideas applied to particle physics

C. Space Technology

The machine shop has been moved into the basement of the Founders Building where the additional area and facilities will contribute to greater efficiency and capabilities. This will help expedite the new rocket and satellite programs which are now being initiated.

D. Other Support to NASA

SCAS provides additional support to NASA in several ways. Dr. F. S. Johnson serves on the Planetary Atmospheres Subcommittee and Drs. W. B. Hanson and J. A. Fejer serve on the Ionospheres and Radio Physics Subcommittee of NASA's Space Science Steering Committee. Dr. F. S. Johnson serves as Chairman, Lunar Atmosphere Measurement Team of the Apollo Science Planning Teams, and as a member of the Voyager Capsule Advisory Group.

E. Contracts and Grants

"A Comparison of Rocket-Borne Probes for Electron Density Measurements,"

NASA Contract NSR 44-004-017, J. A. Fejer and W. J. Heikkila

"Empirical Evaluation of Ion Sheath Effects on a High Frequency Capacitance

Probe with Conical Geometry," NASA Contract, W. J. Heikkila

"Investigations of the Neutral Composition of the Upper Atmosphere,"

NASA Contract NASr-177, W. B. Hanson and T. W. Flowerday

"Investigations into the Mechanism and Rates of Atmospheric Mixing in the

Lower Thermosphere," NASA Grant NGR 44-004-026, F. S. Johnson

"Laboratory Studies of Electron Collision Frequency under Ionospheric

Conditions," NASA Grant NGR 44-004-030, W. J. Heikkila

"Measurement of the Degree of Anisotropy of the Cosmic Radiation Using

the IMP Space Vehicle, NASA Contract NAS5-9075, K. G. McCracken and

W. C. Bartley

"Measurements of the Degree of Anisotropies of the Cosmic Radiation Using

The IQSY Vehicle (PIQSY)," NASA Contract NAS2-1756, K. G. McCracken

and W. C. Bartley

"Measurement of the Degree of Anisotropy of Solar and Galactic Cosmic

Radiation Using the Pioneer Spacecraft," NASA Contract NAS2-3332,

K. G. McCracken and W. C. Bartley

"Multidisciplinary Research in Space-Related Science and Technology,"

NASA Grant NsG-269-62, L. V. Berkner

"For Processing and Interpretation of Data for Pioneers A and B," NASA
Contract NSR 44-004-043, K. G. McCracken and W. C. Bartley

"Procurement and Test of a Prototype Coincidence Mass Spectrometer for
Use in Apollo Missions and Generation of Specifications for a Proof
Test Instrument," NASA Contract NAS 9-4830, F. S. Johnson

"Rocket Probes for Upper F-Region," NASA Contract, L. H. Brace, W. B.
Hanson, and T. W. Flowerday

"A Soft Particle Spectrometer for the ISIS-A Satellite," NASA Contract
NAS5-9112, W. J. Heikkila

"To Develop and Evaluate Techniques and Instrumentation for the Measurement
of Cosmic Radiation Anisotropies," NASA Contract NASr-198, K. G.
McCracken

"Acquisition and Operation of Super-Neutron Stations to Advance the Study
of Cosmic Ray Anisotropy and Other Phenomena Associated with Energetic
Particles," NSF Grant GP-926, K. G. McCracken

"A Co-operative Onshore-Offshore Seismic Experiment," AFCRL Contract
AF49(638)-1542, A. L. Hales

"A Facilities Grant for Construction of a Mass Spectrometer for Potassium-
Argon Analysis," NSF Grant GP-4170, H. Faul

"A Mathematical Theory of the History of the Earth's Atmosphere," NSF
Grant GP-4708 (formerly GP-768), L. V. Berkner and L. C. Marshall

"Analysis of Coexisting Minerals of Garnet-Peridotites from a Number of Kimberlite Pipes in the South African Shield," NSF Grant GP-5142,

B. T. C. Davis and I. D. MacGregor

"Analysis of the Super-Neutron Monitor Data Obtained During the IQSY,"

NSF Grant GP-4688, K. G. McCracken

"Geochronologic Study of Igneous and Metamorphic Rocks in the Southern

Cordillera of Tierra del Fuego, Chile," NSF Grant GA-176, M. Halpern

"Geomagnetic Variations in the Upper Mantle," NSF Grant GP-4650, D. I.

Gough

"Gravity Study," D. I. Gough. This work is being done under Air Force

Contract AF61(052)656 in collaboration with the Observatorio Geofisico Sperimentale, Trieste, Italy, the original contractor.

"Ground-Based Studies of the Geocorona H α Emission and Some Other Night

Sky Emissions, with a Grille Spectrometer," NSF Grant GP-3950, F. S.

Johnson and B. A. Tinsley

"Infrared Absorption Studies," AFCRL Grant AF19(628)-5039, G. N. Plass

"Investigation of the Physical Properties of the Earth's Interior Utilizing

Seismic Wave Propagation, Dispersion, and Attenuation," NSF Grant GP-5544, M. Landisman

"Marine Geophysics Program," ONR Contract Nonr-4455(01), A. L. Hales

"Measurement of Heat Flow in Thermally Stable Lakes," NSF Grant GP-1910,

J. S. Reitzel

"A Program for the Measurement of the Response of the Earth's Crust to
Surface Loading," NSF Grant GP-1335, A. L. Hales

"A Program for Paleomagnetic Research," NSF Grant GP-4099 (formerly
GP-1454), J. W. Graham

"Research Directed Toward Detecting Regional Differences in the Earth's
Mantle," AFCRL Contract AF19(628)-2936, A. L. Hales

"Research in Gravitational Radiation," NSF Grant GP-4962, I. Robinson and
L. Infeld

"Research on General Theorems on Singularities in Spatially Homogeneous
Cosmological Models," AFOSR Grant AF-AFOSR-903-65, I. Ozsvath,
W. Rindler, and I. Robinson

"Research Program to Provide Information on the Primary Hydromagnetic
Spectrum," NSF Grant GP-4339 (formerly GP-2907), J. A. Fejer

"The Spatial Relationships of the Earth's Major Surficial Features During
Portions of Cretaceous Time," NSF Grant GP-2205, C. E. Helsley

"A Study of the Interplanetary Magnetic Field and Its Effect upon the
Cosmic Radiation," AFCRL Contract AF19(628)-5028, K. G. McCracken

"A Study of the Paleomagnetism of Permian and Precambrian Rocks in North
America," American Chemical Society Grant PRF 1829-A-2, C. E. Helsley
(This grant is administered through Southern Methodist University.)

F. Publications

Berkner, L. V. and L. C. Marshall, "Oxygen and evolution," New Scientist, 28, 415-419, 1965.

Colegrove, F. D., W. B. Hanson, and F. S. Johnson, "Eddy diffusion and oxygen transport in the lower thermosphere," J. Geophys. Res., 70, 4931-4941, 1965.

Collins, C. B. "Collisional-dissociative recombination of electrons with molecular ions," Phys. Rev., 140, A1850-A1857, 1965.

Collins, C. B., "Correlation between observed and predicted excited state populations in the helium afterglow," J. Chem. Phys., 43, 3415-3416, 1965.

Collins, C. B. and W. W. Robertson, "Comments on collisional-radiative recombination of He_2^+ into dissociative states," J. Chem. Phys., 43, 4188, 1965.

Ehlers, J., W. Rindler, and R. Penrose, "Energy conservation as the basis of relativistic mechanics, II," Am. J. Phys., 33, 995, 1965.

Fejer, J. A. and W. D. Deering, "Excitation of plasma resonances by a small pulsed dipole," Phys. Fluids, 8, 2066-2079, 1965.

Hales, A. L. and R. W. E. Green, "Single ship seismic refraction studies at sea," Geophysics, XXX, 1236, 1965.

Johnson, F. S., "Atmosphere of Mars," Science, 150, 1445-1448, 1965.

Liemohn, H. B., "Partial electron velocity spectra from cyclotron absorption of whistler power," J. Geophys. Res., 70, 4817-4822, 1965.

Plass, G. N., "The temperature dependence of the mie scattering and absorption cross sections for aluminum oxide," Appl. Optics, 4, 1616-1619, 1965.

Rindler, W., "Elliptic Kruskal-Schwarzschild space," Phys. Rev. Letters, 15, 1965.

G. Papers Presented at Scientific Meetings

Collins, C. B. - Collisional dissociative recombination of molecular ions, 18th Annual Gaseous Electronics Conference, Minneapolis, Minnesota, October 20-22, 1965

Collins, C. B. - Ion-electron recombination processes, 69th Annual Meeting of the Texas Academy of Sciences, Southern Methodist University, Dallas, Texas, December 9-11, 1965

Fejer, J. A. and W. D. Deering - Excitation of plasma resonances by a small pulsed dipole, 1965 Fall URSI Meeting, Dartmouth College, Hanover, New Hampshire, October 4-6, 1965

Fejer, J. A. - Excitation of plasma resonances by an antenna in the ionosphere, Second AAS Symposium on Interactions of Space Vehicles with an Ionized Atmosphere, Miami Beach, Florida, November 26-27, 1965

Fejer, J. A. - Plasma resonance in the ionosphere, 69th Annual Meeting of the Texas Academy of Sciences, Southern Methodist University, Dallas, Texas, December 9-11, 1965

Hales, A. L. - Single ship seismic refraction studies at sea, Society of Exploration Geophysicists, Dallas, Texas, November 14-18, 1965

Hanson, W. B. - Ionization transport in the equatorial F-region, 1965 Fall URSI Meeting, Dartmouth College, Hanover, New Hampshire, October 4-6, 1965

Heikkila, W. J. - Ionospheric probes, 69th Annual Meeting of the Texas Academy of Sciences, Southern Methodist University, Dallas, Texas, December 9-11, 1965

Landisman, M. and Karl Fuchs - Detailed crustal investigations along a north-south section through Central Germany, 37th Annual Meeting of the Eastern Section of the Seismological Society of American, Lamont Geological Observatory, Palisades, New York, October 7-9, 1965

Liemohn, H. B. - Partial electron velocity spectra from cyclotron absorption of whistler power, 1965 Fall URSI Meeting, Dartmouth College, Hanover, New Hampshire, October 4-6, 1965

Midgley, J. E. - Internal gravity waves in the atmosphere, 69th Annual Meeting of the Texas Academy of Sciences, Southern Methodist University, Dallas, Texas, December 9-11, 1965

Oetking, P. - A geological comparison of the moon to the earth, Science Teachers of Dallas, School Administration Building, Dallas, Texas, November 17, 1965

Oetking, P. - Modern geology, Science Educators Association, St. Marks Science Lecture Hall, Dallas, Texas, December 14, 1965

Oetking, P. - Geological features: moon versus earth, Science Club of Kimball High School, Dallas, Texas, December 15, 1965

H. Lectures by Visiting Scientists

Axford, Ian - The Wind Shear Theory of Temperate Zone Sporadic E,
October 8, 1965, Cornell University, Ithaca, New York

Fehsenfeld, Fred C. - Laboratory Measurements of Ion-Molecule Reaction
Rates, December 15, 1965, ESSA, Boulder, Colorado

Hall, James E. - Rocket Studies of the D-Region using an L.F. Radio
Propagation Technique, October 5, 1965, Radio and Space Research
Station, Slough, England

Owen, D. B. - Sampling Procedures in Quality Control, November 24, 1965,
Division of Mathematical and Stochastic Systems, Southwest Center for
Advanced Studies, Dallas, Texas

Palmeira, Ricardo - Some Considerations on the Low Energy Proton and
Alpha Cosmic Ray Spectrum, October 5, 1965, Goddard Space Flight
Center, Greenbelt, Maryland

Thompson, W. B. - Radiation as a Plasma Probe, December 1, 1965, University
of California at San Diego, San Diego, California

I. Scientific Staff, Earth and Planetary Sciences Laboratory

Ables, Mr. Jon G. (Graduate Student)
Adair, Mr. Carlos H. (Supervisor - Electronics Technicians)
Anderson, Mr. John E. (Instrument Maker)
Anschutz, Mr. LeRoy D. (Electronics Technician)
Bacon, Mr. D. Lee (Electronics Technician)
Barber, Mr. Dennis D. (Electronics Technician)
Bartley, Mr. William C. (Research Scientist)
Belflower, Mrs. Doyce D. (Research Assistant)
Bell, Mr. Eugene J. (Technician)
Bernhardt, Mr. Brian M. (Machinist)
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Bickel, Mr. Richard L. (Engineering Support Group/Supervisor)
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Bonham, Mr. Alba J. (Electronics Experiments Supervisor)
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Cahen, Dr. Michel (Associate Professor)
Carnahan, Mr. Joe B. (Draftsman)
Carroll, Mr. James M. (Electrical Engineer)
Carter, Dr. James L. (Research Associate)
Clarke, Mr. Arthur A. (Nighttime Observer)
Colegrove, Dr. Forrest D. (Visiting Scientist)
Collins, Dr. Carl B. (Assistant Professor)
Corwin, Mr. James C. (Associate Engineer)
Couch, Miss Yvonne (Research Analyst)
Davis, Dr. Brian C. (Assistant Professor)
Donaldson, Mr. Jack S. (Visiting Scientist)
Dowling, Dr. John J. (Research Associate)
Doyle, Mr. Hugh A. (Research Associate)
Dziewonski, Dr. Adam (Research Associate)
Eaker, Mr. Nick (Project Engineer)
Edmondson, Mr. David B. (Electronics Technician)
Edwards, Dr. P. J. (Assistant Professor)
Ehlers, Dr. Jürgen (Visiting Associate Professor)
Faul, Dr. Henry (Professor)
Fejer, Dr. Jules A. (Professor)
Flowerday, Mr. Thomas W. (Research Scientist)
Gladden, Mr. Jimmy W. (Machinist)
Glasscock, Mr. Harold W. (Electronics Engineer)
Gottlieb, Dr. Benjamin (Research Associate)
Gough, Dr. D. Ian (Associate Professor)
Graham, Dr. John W. (Professor)
Green, Mr. A. W., Jr., (Visiting Scientist)

Green, Mr. R. W. E. (Research Scientist)
Gronstal, Mr. Philip T. (Research Scientist)
Haas, Mr. Herbert (Engineering Technician)
Hales, Dr. Anton L. (Division Head and Professor)
Hall, Mr. Thomas O. (Technician)
Halpern, Dr. Martin (Research Associate)
Hammack, Mr. Hilton D. (Electronics Technician)
Hanson, Dr. William B. (Professor)
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Harries, Mr. John R. (Research Assistant)
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Helsley, Dr. Charles E. (Associate Professor)
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Hodges, Dr. R. Richard, Jr., (Research Scientist)
Hoffman, Dr. A. A. J. (Adjunct Assistant Professor)
Holmquist, Dr. Fred N. (Scientist)
Huckaby, Mrs. Antoinette H. (Laboratory Technician)
Hurt, Dr. Worth B. (Research Associate)
Infeld, Leopold (Visiting Professor)
Jackson, Dr. Henry W. (Visiting Scientist)
Jenkins, Mr. William (Laboratory Technician)
Johnson, Dr. Francis S. (Laboratory Director, Division Head, and Professor)
Jones, Mr. Lloyd E. (Glassblower)
Jones, Mr. Theodore (Apprentice Machinist)
Keath, Mr. Edwin P. (Graduate Student)
Keiller, Mr. John A. (Instrument Engineer)
Kraft, Mr. Joseph A. (Electronics Technician)
Landisman, Dr. Mark (Professor)
Lee, Mr. Edward C. (Technician)
LeFan, Mr. Billy W. (Engineer)
Leroy, Mr. Jules (Graduate Student)
Lichnerogicz, Andre L. (Visiting Professor)
Liemohn, Dr. Harold B. (Assistant Professor)
Lim, Mr. Phillip (Technician)
Lippincott, Mr. Charles R. (Associate Instrumentation Engineer)
MacGregor, Dr. Ian D. (Assistant Professor)
Manton, Mr. William I. (Research Scientist)
Marshall, Dr. L. C. (Professor)
Martin, Mr. Billy (Machinist)
Martin, Mr. David J. (Technician)
McCracken, Dr. Kenneth G. (Professor)
Mercer, Mr. Thomas B. (Laboratory Technician)
Midgley, Dr. James E. (Assistant Professor)
Milam, Mr. Billy P. (Electronics Technician)
Mitchell, Mr. Ronald G. (Illustrator)
Morgan, Mr. Richard H. (Mechanical Engineer)
Morpheus, Mr. James R. (Electronics Technician)
Nation, Mr. Joseph B. (Research Assistant)

Ne'eman, Yuval, (Visiting Professor)
Nieh, Mr. Sidney T. K. (Laboratory Assistant)
O'Dell, Mr. H. Frank (Supervisor-Machine Shop)
Odom, Mr. William J. (Electronics Engineer)
Oetking, Dr. Philip (Research Scientist)
Ozsváth, Dr. István (Associate Professor)
Page, Mr. Harry L. (Laboratory Technician)
Patterson, Dr. T. N. L. (Visiting Scientist, Summer)
Pepper, Mr. William L. (Electronics Technician)
Peters, Mr. Carl (Programmer)
Pittsinger, Mr. Elmer (Machinist)
Plass, Dr. Gilbert N. (Professor)
Price, Mrs. Mary H. (Laboratory Technician)
Porter, Mr. John R. (Graduate Student)
Randazzo, Mr. Salvador P. (Electronics Technician)
Reitzel, Dr. John S. (Assistant Professor)
Riley, Dr. Glen H. (Research Associate)
Rindler, Dr. Wolfgang A. (Associate Professor)
Roberts, Mrs. Jeanne (Programmer)
Robinson, Professor Ivor (Division Head and Professor)
Seibel, Mr. David W. (Laboratory Assistant)
Shippy, Mr. Chester (Mechanical Designer)
Smith, Mr. Gerald W. (Laboratory Technician)
Smith, Mr. Jesse B. (Research Scientist)
Spall, Mr. Henry R. (Graduate Student)
Stang, Mr. Donald R. (Electronics Engineer)
Steele, Mr. Gordon R. (Associate Engineer)
Steinbock, Miss Mary (Graduate Student)
Stokes, Mr. Gordon A. (Electronics Assembly Supervisor)
Swaim, Mr. Loyd A. (Senior Electronics Technician)
Tarstrup, Mr. Jens (Electronics Engineer)
Thompson, Mr. Charley R. (Electronics Technician)
Tinsley, Dr. Brian A. (Research Associate)
Tipple, Mr. Karl R. (Research Engineer)
Tolle, Mr. Melvin L. (Laboratory Technician)
Toney, Mr. James B. (Electronics Technician)
Verhoogen, Dr. John (Consulting Professor)
Walker, Mr. E. Alan (Illustrator)
Wheless, Mr. J. E. (Mechanical Designer)
Wilson, Mr. Warren L. (Electronics Technician)
Wright, Dr. W. H. (Research Associate)
York, Mr. Douglas (Laboratory Technician)
York, Mr. James E. (Draftsman)
Younse, Mr. Jack M. (Electronics Engineer)

J. Symposia

Berkner, L. V. and L. C. Marshall - "Oxygen in the Earth's Atmosphere,"
Exobiology Seminar, Southwest Center for Advanced Studies, October 19,
1965

Berkner, L. V. and L. C. Marshall - "The Origin, Rise, and Stability of
the Earth's Atmosphere," University of Miami, December 1, 1965

Hales, A. L. - "The Surfaces of Earth and the Planets," Exobiology
Seminar, Southwest Center for Advanced Studies, October 15, 1965

Hales, A. L. - "Problems of the Upper Mantel" and "Seismic Refraction
Measurements at Sea," Southeast Missouri State College, Cap Girardeau,
Missouri, December 9, 1965

Hales, A. L. - "Problems of the Upper Mantle," University of Missouri,
Columbia, Missouri, December 10, 1965

Johnson, F. S. - "Weather and Weather Modification," Sigma Pi Sigma
Chapter, North Texas State University, Denton, Texas, November 23, 1965

Johnson, F. S. - "Planetary Atmospheres," Exobiology Seminar, Southwest
Center for Advanced Studies, December 16, 1965

Liemohn, H. B. and L. L. Baggerly - "Report on the NATO Advanced Study
Institute in Bergen, Norway," Texas Christian University, Ft. Worth,
Texas, October 15, 1965

Liemohn, H. B. and J. E. Midgley - "Gravity Waves in the Atmosphere,"

Southwest Center for Advanced Studies, November 19, 1965

McCracken, K. G. - "Cosmic Ray Modulation by the Solar System," Cornell

University, Ithaca, New York, October 21, 1965